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A PRECISION METHOD FOR MEASURING TEMPERATURES OF REFRACTIVE INDEX LIQUIDS ON A CRYSTAL REFRACTOMETER AND ON A MICROSCOPE SLIDE[1]

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In connection with comprehensive investigations on portland cement, it has been necessary to develop methods of high precision for the identification and study of the several compounds and solid solutions which are encountered. This report presents such a method for the measurement of temperature in the determination of refractive indices. It is believed that the method will be generally useful to the microscopist engaged in any work requiring the accurate temperature measurement of single drops of liquid.

In checking refractive index values on liquids at intervals of a day or more, using an Abbe crystal refractometer, variations in index have been indicated which could not be ascribed to changes in the liquid itself. The values occasionally changed by as much as .0015 to .0017 on consecutive days and the variations were sometimes positive and sometimes negative in character. A careful study of the whole procedure indicated that the values used for the temperature of the liquids were subject to significant errors.

The change in refractive index for each degree of temperature change for liquids of $n = 1.700$ and higher is .0006 to .0007. Therefore, if the value of the refractive index of such liquids is to be determined to the third decimal place, the temperature of the liquid must be known to about 1°, since other errors, though perhaps smaller, must be allowed for.

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[1] Publication approved by the Director of the National Bureau of Standards, U. S. Department of Commerce. Paper No. 16 of the *Portland Cement Association Fellowship* at the *Bureau of Standards.*

The writers have found that by using a differential thermocouple, the temperature of the liquid on the refractometer can be measured with the desired accuracy. This procedure may be employed, also, to measure the temperature of the liquid while in use on a slide on a microscope thus eliminating another probable source of error in the determinations of refractive indices of solids by microscopic methods. Seidentopf,[2] in 1906, mentioned the use of a thermocouple for measuring the temperature of a liquid on a slide. The suggestion, however, appears not to have been adopted by microscopists in this country.

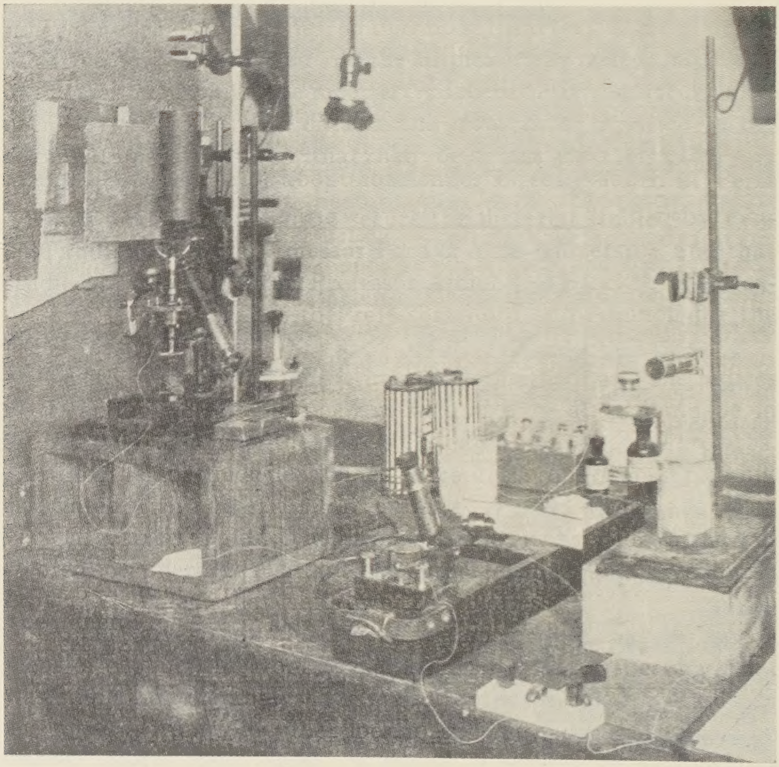

Fig. 1. Suggested arrangement showing (1) differential thermocouple with flattened junction in place on refractometer, (2) the method of protecting the thermometer bulb and its thermocouple junction, and (3) the portable galvanometer used in the work.

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[2] *Z. Elektrochem.*, 12 (1906), 596.

SUGGESTED PROCEDURE

The method described below differs from those commonly used in two essential points: (1), the location and protection of the thermometer; and (2) the use of a differential thermocouple to measure temperature differences. A photograph showing the arrangement of the apparatus is reproduced in Fig. 1. The Abbe crystal refractometer (hemisphere of $N_D = 1.7972 \pm .0001$) is shielded from the Bunsen burner (the source of monochromatic light) by a wooden shield with a movable ground glass window and by a second cardboard shield[3] close to the hemisphere. The small lamp—a 6 to 8 volt Mazda bulb operated from dry cells—is a convenient light for reading the scales and gives a negligible amount of heat.

The mercurial reference thermometer used to measure the temperature of one junction is of the precision type, calibrated at several points near room temperatures. It has a temperature range of 0°–40° over a scale length of about 30 cm. and is graduated in tenths of a degree. By the aid of the small reading glass shown in the Figure, it can be read easily to 0.05°. In the arrangement of apparatus suggested, the bulb and part of the stem of the thermometer are placed in a glass jar, packed with loose cotton. This insulation is necessary to insure a reasonably close agreement in the temperatures of the thermometer bulb and the attached thermocouple junction. It also insulates the system to a considerable degree from minor fluctuations in air temperature, and makes the temperature "lag" of the thermometer more equal to the lags of the refractometer and the microscope.

The galvanometer shown in Fig. 1 is a very compact, portable instrument of the d'Arsonval type, such as is used for insulation testing. It should have a sensitivity of about 3 micro-volts per scale division.

The thermocouple[4] is conveniently made of two pieces of No.

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[3] The cylindrical shield hung above the hemisphere is used only when the face of the operator is close to the liquid for some time, as then the heat from the breath causes a slight rise in the temperature of the liquid.

[4] The construction and connections of the thermocouple may be seen from Fig. 2. A and B, cotton-covered copper wire, No. 36; C, cotton-covered constantan wire, No. 36; G, galvanometer; S, switch; 1, junction to be in contact with the thermometer bulb; 2, flattened junction to be placed in liquid.

When junctions 1 and 2 are at different temperatures, completing the circuit by closing the switch (S) causes deflections in the galvanometer, which for small

36 cotton-covered copper wire silver-soldered to the ends of a similar wire of constantan, with one of the junctions rolled to a thin ribbon.

The galvanometer scale and thermocouple must be calibrated[5] for small known temperature differences (0°–5°), and then, when arranged as shown in Fig. 1, can be used in conjunction with the thermometer to obtain the correct temperature of the liquid.[6]

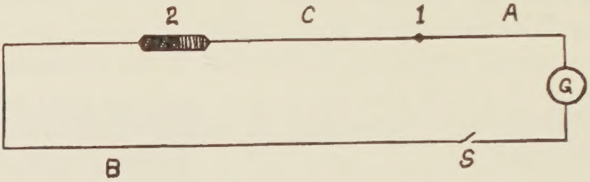

Fig. 2. Wiring diagram for the thermocouple and galvanometer.

The accuracy with which changes in temperature of the liquid on a refractometer can be followed by this method, is shown by the data in Table I, which are taken from one of the trial runs. The liquid used was a sample of pure monobrom-naphthalene.

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values near the center of the scale, are practically proportional to the temperature differences. If then, the value of the scale deflections, in terms of temperature, is known and the temperature of one junction can be read by means of a thermometer, there is provided a means of determining the temperature of the other junction very accurately.

[5] The thermocouple and galvanometer scale may be calibrated by noting the deflections resulting from known small (0°–5°) differences in temperature. The two junctions may be inserted in two separate thermos bottles containing water and calibrated thermometers. The temperature difference and the corresponding galvanometer deflection are then obtained. Several such measurements for other temperature differences should be made, and the value of one scale division in terms of temperature calculated from the mean.

[6] The following procedure is suggested: The apparatus is arranged as shown in Fig. 1, with the flattened junction of the thermocouple on the hemisphere and just to the right of the center. (It may be held in place by fastening the lead-wires to the refractometer with modeling clay). The liquid is placed on the hemisphere and the junction and liquid covered with a piece of foil, which keeps the liquid in place on the junction. The switch is closed and the refractometer set at the critical angle. The galvanometer and thermometer scales are read and the switch opened. The refractometer scale is next read and then the null point of the galvanometer is obtained. The temperature of the liquid is then calculated as the algebraic sum of the corrected thermometer reading and the temperature value of the observed galvanometer deflections.

Table I

Time in minutes after first reading	Corrected Thermometer Reading	Critical Angle[a]	Calculated Temperature of Liquid	Refractive Index at 21°. Calculated from liquid temperature[b]
0	25.3	67° 13.5′	24.9	1.6589
2	25.4	67° 13.5′	25.1	1.6590
4	25.5	67° 13.5′	25.2	1.6591
7	25.5	67° 12.5′	25.4	1.6590
9	25.5	67° 12.0′	25.4	1.6589
11	25.5	67° 12.0′	25.5	1.6589
13	25.5	67° 12.0′	25.5	1.6589
15	25.6	67° 11.5′	25.6	1.6589
17	25.7	67° 11.0′	25.8	1.6590
19	25.8	67° 11.0′	25.9	1.6589
21	25.8	67° 11.0′	25.9	1.6589

[a] Angular readings are the means of three settings.

[b] For calculating *n* at 21°, the value dn/dt = .00048 was used. See Larson, Bulletin 679, *U. S. Geol. Survey.*

Attention is called to two points shown in the above data.

The refractive index calculated to 21° is practically constant, indicating a very close agreement between observed changes in critical angle and changes in temperature as measured by this method.

The temperatures of the thermometer and of the liquid rose steadily (without measurable fluctuations) but at slightly different rates. The slow and regular character of the changes makes for greater accuracy in the calculated values of the liquid temperature, and does not obtain if the thermometer is used unprotected.

Other series of determinations were made on the same liquid on other days when the temperature of the room was different. Three of such series are summarized in Table II.

Table II

Trial	Number of Readings	*n* at 21° Calculated from Temp. of Liquid	Variation
1	11	1.6590	1.6589–1.6591
2	5	1.6592	1.6591–1.6592
3	6	1.6591	1.6590–1.6591

The consistency of the results obtained in these trials indicates that the measurements of the temperature were satisfactory.

USE OF THERMOCOUPLE AT THE MICROSCOPE

When determining the refractive indices of solids by the immersion methods on a microscope, the temperature of the liquid surrounding the grains must be known. The thermocouple described above can be used to determine this temperature to a high degree of precision and with but very little inconvenience. The same arrangement of thermocouple, galvanometer and protected thermometer is employed. The flattened junction is placed under one end of the cover glass and held in place by attaching the lead-wires to the slide with modeling clay. The method of procedure is similar to that used with the refractometer and the method of calculating the temperature is the same.

USE OF MERCURIAL THERMOMETERS IN REFRACTOMETRY

The differential thermocouple and thermometer described above were used to measure the differences between the temperature of a liquid on the refractometer and that of a second unprotected thermometer, when hanging at different places near the instrument, corresponding to those commonly used.

Depending on the location of the thermometer, the differences between the temperatures of the liquid and of the uninsulated thermometer varied in amount, being as high as 5° in some cases. For any given location of the thermometer, the temperature difference was often quite variable, even within relatively short time intervals, and was sometimes positive and sometimes negative in character. These variations may be explained, in part at least, by the observation that the thermocouple responds more rapidly to variations in temperature than does the attached mercurial thermometer. This also indicates the need for suitable insulation of the thermometer bulb and its attached junction.

The best agreement between the temperatures of the liquid and uninsulated thermometer was obtained when the latter was hung about 2 mm. above the liquid and protected by the cylindrical shield as shown in Fig. 1. With this arrangement, the temperature difference generally increased rapidly for a few minutes after the flame was turned on, the thermometer being at the higher temperature. Later the difference decreased, sometimes passing through zero and becoming negative. The final temperature differences though at times larger were generally within ±1°, indicating that such an arrangement may be satisfactory for routine work, although not reliable when precise data are desired.

Measurements similar to those just described were made, also, at the microscope. Unprotected thermometers, hung at several places near the instrument, were read at the same time the temperature of the liquid on the microscope slide was determined by the thermocouple and the protected thermometer.

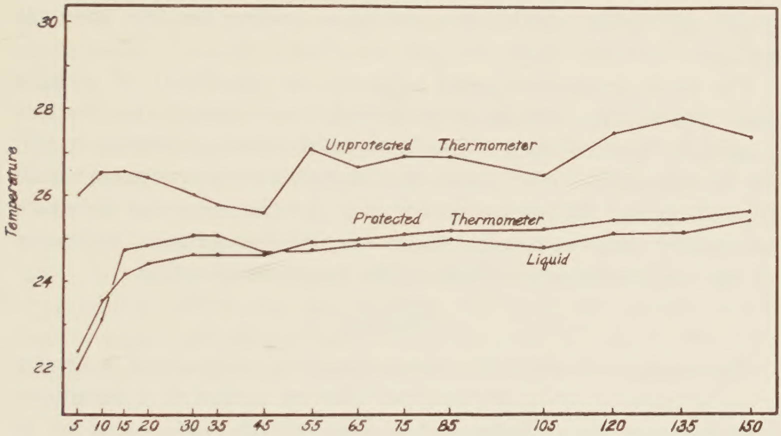

Fig. 3. Curve showing changes in temperature with time following the turning on of light at the microscope.

The data shown in Fig. 3 are typical of those obtained. In this trial all the apparatus and the liquid had been on the same table over night and the liquid had been in place on the microscope for some time before the lamp was turned on. However, five minutes after turning on the lamp, the unprotected thermometer registered a temperature about 4° higher than that of the liquid. During the entire trial, the unprotected thermometer hanging about 30 cm. from the microscope showed a temperature which was higher and more variable than that of the liquid. The significance of the temperature differences obtaining with such arrangements for temperature measurements may be clearer if stated in terms of refractive index. In the trial run reported in Fig. 3, the refractive index of a grain matching a liquid with $n=1.700$ ($dn/dt=.0006$) would have been too low by amounts varying from .0004 to .0023.

Examination of Fig. 3 shows a close agreement between the temperatures of the liquid and those of the protected thermometer used with the thermocouple. The differences in temperature measured by this arrangement of apparatus are small and therefore give rise to only small deflections near the center of the galvanometer scale. Were the reference junction immersed in a liquid in a thermos bottle, its temperature would remain sensibly constant and the galvanometer deflections would therefore be larger and more variable—a condition making for less accurate results.

The close agreement noted suggests the possibility of using a good thermometer similarly protected, but without the thermocouple, for routine work where temperature measurements to $\pm 2°$ are satisfactory. A few trials should indicate the proper amount of packing and the proper location of the thermometer to insure reasonably close agreement between the temperature indicated by the thermometer and that of the liquid on the slide.

SUMMARY

The measurement of the temperature of a liquid on a crystal refractometer or on a microscope slide by means of a thermometer hung in the vicinity of the instruments was found to be unreliable.

A method is described by which these temperatures can be measured with the accuracy required when refractive indices are to be determined to 0.001. The method is simple in operation and requires apparatus which is relatively inexpensive.

I. THUCHOLITE, A REMARKABLE PRIMARY CARBON MINERAL FROM THE VICINITY OF PARRY SOUND, ONTARIO

II. CYRTOLITE INTERGROWTH ASSOCIATED WITH THE PARRY SOUND THUCHOLITE

H. V. Ellsworth*, *Canada Geological Survey.*

I. THUCHOLITE

A pegmatite dike which traverses the line between lots 9 and 10, conc. IX, Conger township, Parry Sound District, carries a number of rare mineral species, including uraninite,[1] calcio-samarskite[2], allanite, and the two minerals described in these papers.

As seen by the writer, the dike was exposed for 70 feet along the north side of a small hill on the shore of Blackstone Lake. It had been uncovered for the most part by stripping, but as the contacts with the country rock were not exposed except for some small patches of hornblendic gneiss at the eastern end of the dike, it was not possible to ascertain the dip and strike, nor the true width. However, the exposed width on the hillside was 60 feet or more and the probable strike about N 60° E. It may be a comparatively narrow dike dipping to the north along the slope of the hill.

About one half of the exposed dike surface was massive white quartz with occasional inclusions of crystal microcline up to a foot or more in diameter, and large crystals of muscovite some of which reached a diameter of 18 inches, but were rarely if ever over an inch or two thick, i.e., along the *c* axis. These large muscovite crystals usually occurred at the contact of the massive white quartz and feldspar, sometimes parallel to the contact, sometimes normal to it, in which latter case one half the diameter of the mica book would be imbedded in quartz, the other half in feldspar. Sheets of bent and crumpled very black biotite, as much as two feet in diameter, were seen at the contact of the massive quartz with the granular quartz-feldspar-mica mixture. A few small flakes of molybdenite were found but this mineral is rare.

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[1] *Geol. Survey Canada,* Summary Rept., **1921**, Part D, p. 60D et seq.

[2] This Journal, Volume **13**, p. 66, 1928.

The other half of the exposed dike surface consisted mainly of a granular mixture of smoky quartz, pink to red feldspar in which more or less polysynthetic twinning could usually be seen, and small thin crystals of muscovite and biotite, chiefly the former. Some patches of crystals of microcline up to 2 or 3 feet in diameter and other patches in which muscovite, and to a less extent biotite, occur in irregular clusters and fan shaped aggregates of thin crystals, are also included in this area. Uraninite occurs as scattered crystals in this part of the dike, particularly in association with stringers and aggregates of thin muscovite crystals, sometimes actually embedded in the mica, sometimes in quartz or feldspar usually near the mica. The uraninite crystals vary from $\frac{1}{8}$ inch to a rare maximum of one inch in diameter, the average being $\frac{1}{4}$ inch or less. The crystals are cubic in habit showing usually only a small development of the octahedron.

Calciosamarskite was found in much less quantity than uraninite though under the same conditions, except that it seems to be more closely associated with the biotite. Associated with both uraninite and calciosamarskite are occasional occurrences of a black mineral, the thucholite of this paper, which might easily be mistaken for uraninite when embedded in the rock except that it never shows indications of crystal form. The thucholite occurs in exactly the same way as the uraninite, embedded in feldspar, quartz or mica, or in a mixture of all three and is certainly just as much a primary mineral as are any of those just mentioned (Fig. 1). It takes the form of irregular rounded nodules or more or less roughly globular masses from 1 millimeter to one inch in diameter (Fig. 2). In the form of small round grains, 1 to 3 millimeters in diameter, it is rather abundant in some of the finer grained parts of the granular mixture of smoky quartz, feldspar and small mica where uraninite does not occur. Occasionally a uraninite crystal is completely embedded in thucholite and the calciosamarskite also is sometimes in contact with it. A few of the nodules collected were clean, lustrous and homogeneous throughout from center to outside, some have an irregular cavity in the center containing crumbly, decomposed, highly uraniferous material which appears to have been originally uraninite, and one was collected which still contained a core of fairly well preserved uraninite. The majority, however, while consisting internally of pure lustrous thucholite were outwardly more or less intergrown with the cyrtolite intergrowth described in II. The outer surface of thucholite nodules usually also contains minute embedded scales of white and black mica. The latter is very black and opaque except in the thinnest possible cleavages. It is biaxial with 2E = 50°, approximately. Such chemical tests as it was possible to make on the small quantities available did not indicate that it was different from ordinary biotite. One might suspect it to contain uranium and vanadium but the possibility of contamination from its associates would in any case render results on such small quantities dubious. Associated with the cyrtolite and black mica on some of the thucholite nodules are small patches of a powdery white mineral (Fig. 2-B) apparently a decomposition product, which so far as it has been examined appears to be a new mineral, a hydrous phosphate or silico-phosphate of calcium and yttrium earths. As this mineral can only be isolated in the most minute quantities much more work will have to be done before it can be fully described.

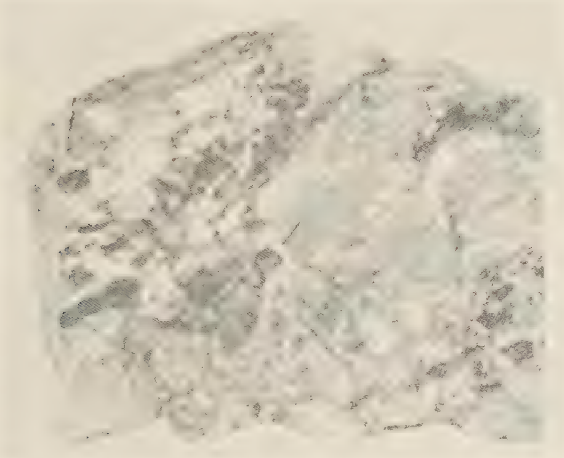

Fig. 1. Photograph about natural size showing thucholite nodule, indicated by arrow, in a mixture of feldspar, white and smoky quartz.

It appears likely that the thucholite varies considerably in composition. Nodules which are intimately in contact with uraninite naturally would be likely to carry more uranium than usual, and the ash of such specimens in fact is sometimes almost black and highly uraniferous, while the ash at other times may be cream colored, greenish (from presence of V) or yellowish. Thucholite was first identified by the writer in 1921 but it was not until some years later that enough of the material was obtained to justify undertaking quantitative studies. Finally about 10 grams was assembled and from this lot small fragments of the most lustrous material free from any visible impurities were carefully selected for the tests under a binocular microscope equipped with a Silverman Illuminator.

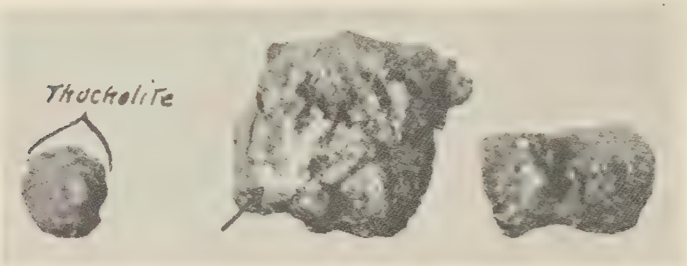

Fig. 2. Specimens of Parry Sound thucholite about twice natural size.

A Uraninite nodule originally completely enclosed by thucholite coating, part of which is still visible at the top.

B Thucholite mass showing the white mineral mentioned in Part II, indicated by arrow.

C Typical thucholite nodule showing rounded outlines.

Physical Properties, Pyrognostics, Etc.

Thucholite is jet black with brilliant lustre and perfect conchoidal fracture. Cleavage none. Very brittle. Hardness 3.5 to nearly 4. It is absolutely opaque even in the smallest grains with arc illumination. Sp. Gr. = 1.777 at 17.74°. In the closed tube yields much water but no hydrocarbons.[3] Fragments if quickly heated may explode into powder with considerable violence, the particles being projected in all directions. It evolves gas copiously if immersed in water and heated. Digestion with 10 per cent HCl removes the greater part of the rare element constituents, and the solution if filtered and evaporated shows the yellowish green color due to uranium (yellow) and vanadium (green). Concentrated nitric acid at the boiling temperature slowly attacks the thucholite, the acid becoming brown colored. The carbon can be completely destroyed by heating with concentrated H_2SO_4 and KNO_3. Concentrated cold H_2SO_4 seems to have little or no effect on the carbon, with long heating, however, the acid becomes brown colored. Strong hydrochloric acid (33 per cent HCl) can be boiled with the mineral for hours without becoming colored in the slightest degree by carbon compounds. Of course any of the mineral acids dissolve out the rare element compounds. The mineral burns slowly in air when maintained at a red heat yielding a light, pulverulent ashy residue. The ash retains to a great extent the shape of the original fragments, but with some reduction in size, though it crumbles to fine powder at the slightest touch. Under the binocular microscope it very closely resembles fragments of dried bentonite. The prevailing color of the ash fragments is a creamy-yellow but almost an equal number are greenish, and occasional minute black specks may be seen where no doubt there was a concentration of uranium. Some fragments may be in part greenish, in part yellowish. As obtained by ignition it shows no sign of fusion at a high red or nearly white heat in a platinum crucible heated over a large Meker burner.

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[3] The mineral of course shows considerable radioactivity easily detectable in the electroscope and it produces the same radial fracturing in feldspar or quartz enclosing it as do other radioactive minerals.

Attempts to make sections thin enough to transmit light were unsuccessful, but a very good polished surface was obtained by first embedding a nodule in dentist's phosphate cement, grinding and polishing as usual. When examined by reflected light, this surface appeared to be entirely homogeneous, even under the highest powers, except for a few minute hair-like lines near the outer edge, which stood in slightly higher relief. These lines looked much like extremely minute cracks which had been filled with some harder material of the same nature. The proportion of this harder material would be much less than one per cent of the surface examined.

Composition

Three different samples of approximately 0.1 gram gave by combustion in oxygen; carbon = 45.18, 42.24, 50.48 per cent. No precautions were taken to insure complete combustion of CO and probably these results are low.

Three different samples (not corresponding to above) yielded results as follows:

	I	II	III
H_2O at 110°	7.64	8.63	8.40
H_2O total, direct	13.20	13.02	12.96
Ash	24.48	24.20	28.06

The purpose of the foregoing experiments was to find out whether the substance has a constant composition. Unfortunately it was not practicable to obtain each sample from one nugget only, so that possibly all the samples represented more or less of an average of the lot from which they were selected.

The ash of various determinations was combined and analyzed with the following results:

Analysis of 0.40 gram Freshly Ignited Ash of Thucholite, Parry Sound, Ont.

Water soluble (Not definitely identified)	1.60	
PbO	0.20	
U_3O_8	5.80	
ThO_2	48.48	
$(Ce, La, Di)_2O_3$	5.45	
$(Yt, Er)_2O_3$	10.95	
Fe_2O_3	1.50	
V_2O_3	2.25	
MnO	0.02	
TiO_2	doubtful trace	
Al_2O_3, etc.	1.45	
[1]CaO	0.50	(3.00)
MgO	traces	
ZrO_2	0.80	
[2]K_2O	0.15	
[3]Na_2O	0.22	
P_2O_5	3.21	
SiO_2	14.70	
NiO CoO } Not detected on small separate amount of ash		
	97.28	

[1] Probably should be about 3.00 per cent.

[2] Alkalies pptd. by Pt.

[3] Alkalies not pptd. by Pt.

If a larger quantity of ash had been available it would doubtless have been possible to attain a more satisfactory summation. As it was, all the consituents had to be sought for and determined in the one small lot, and as nearly half of the ash was thorium oxide all the other constituents together amounted to only about 0.2 gram. The low total is believed to be due to slight losses incident to the necessarily complicated analytical procedure rather than to failure to determine some constituent or constituents actually present. A review of the analytical notes indicates that possibly much of the deficiency was due to slight losses of lime occasioned by repeated operations on other substances from which the lime was supposed to be completely separated but actually was not. Thus it seems likely that most of the missing 3 per cent should be credited to CaO, especially as this amount was subsequently found on another sample in 1927. Owing to the presence of phosphorus, vanadium and zirconium, numerous operations and exceptional precautions were necessary to ensure pure precipitates, especially in the case of uranium and thorium, hence these are probably slightly low. With the exception of the ZrO_2, which, being small in amount, was not especially purified, the analytical results as given therefore represent minimum percentages of the constituents present, and as thus defined are believed to be trustworthy. Vanadium was separated with certainty from uranium by cupferron. The thorium weighed was free from zirconium.

RADIOACTIVITY OF THE ASH

Previous to the analysis, the radioactivity of the ash was compared with that of standard analyzed carnotite in a U. S. Bureau of Mines type α-ray electroscope. Equal weights and surface areas of ash and 1.55 per cent U_3O_8 carnotite were compared, with the result that the ash was found to be 13.6 times as active as the carnotite, indicating an activity equivalent to 21.08 per cent U_3O_8, which agrees quite well with the analytical results (24.9 per cent U_3O_8 equivalent), considering that radon and thoron were doubtless driven off by the ignition and that the test was made before they had again reached equilibrium. In view of the small amount of lead found it would have been interesting to have determined radium and mesothorium accurately by the emanation method to see whether these were present in amounts corresponding to the normal equilibrium ratio, or in other words, to see whether lead only is being removed faster than it is formed, or whether not only lead but also radium and mesothorium are being leached away.

An attempt to determine the gas content by weight was carried out as follows. The sample in fragments was introduced into a small silica tube closed at one end, which was weighed before and after. Crushed and sifted, freshly ignited, transparent, fused silica was then inserted on top of the mineral to prevent loss by decrepitation and a plug of dry glass wool was inserted to hold down the fused silica powder. The whole was then weighed and attached to a mercury vapor vacuum pump. After exhausting until long after all air had been removed the mineral was gradually heated to a white heat with a gas blast lamp, the heating being continued until tests with the McLeod gauge attached to the pump indicated that only unweighable quatities of gas were coming off. The tube was allowed to cool, was detached from the pump and weighed. The results are given below:

	Per Cent
Loss by vacuum ignition	26.08
H_2O—direct, same sample	(12.96)
Gas by difference	(13.12)
Ash—same sample	28.06
Fixed Carbon, by difference	45.86
	100.00

Occurrences of diamonds in pegmatites have been reported[4] and it was thought to be worth while to look for them in the thucholite ash, but none were found.[5] During the washing of the silica of the analysis some very minute almost perfectly spherical balls attracted attention by rolling around in the platinum dish. These had withstood the action of concentrated H_2SO_4 over night at the fuming temperature. Three were secured for examination. Two measured a little less than 0.1 mm. in diameter while the largest was nearly 0.4 mm. across. Immersed in oils under the microscope the large ball was absolutely isotropic with index$=1.518$ and contained numerous minute bubbles or inclusions. The color of the balls varied from colorless to greenish.

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[4] According to Mellor, A Comprehensive Treatise on Inorganic and Theoretical Chemistry, Vol. V, p. 737—"M. Chaper found diamonds in the pegmatites of Bellary, Madras."

[5] After treatment with HF and H_2SO_4 any small residue of lead sulfate, etc., is completely soluble in HCl leaving not the slightest trace of insoluble material.

It was suspected that these balls might have been produced by fusion of ash around concentrations of material rich in alkalies or phosphates, but if that were so their resistance to fuming sulfuric acid is rather surprising. About 0.2 gram of the thucholite in small fragments was destroyed by heating with concentrated H_2SO_4 and KNO_3 and no balls or insoluble residue were seen in this solution. Since, however, only a half dozen balls were seen in 0.4 gram of ash they might exist in the original material and still be missed by the wet test on the small quantity.

The foregoing work was performed some years ago by the writer. Last year Dr. A. L. Day, Director of the Geophysical Laboratory, Washington, very kindly enlisted the services of Dr. E. S. Shepherd, the noted authority on volcanic gases and gas analysis, for an investigation of the gas content of thucholite. By permission of Dr. Day the report of Dr. Shepherd covering his analysis of the gases of thucholite, is reproduced below.

THE VOLATILES IN THUCHOLITE

E. S. Shepherd

"Dr. H. E. Mervin with the aid of the binocular microscope kindly selected from the better sample submitted some three decigrams of the most homogeneous seen.

Methods.—A slight variation of the regular procedure was thought advisable. The mineral was placed in a small platinum capsule equipped with a fairly tight lid, which was wired on. This capsule was then placed in a Lawrence Smith Alkali tube containing pure CaO. The tube was capped and the cap secured. The combined tubes were then placed in the silica tube in the furnace and the exhaustion carried out as described in my paper on methods.[6] Of course the platinum, silica and CaO had all been previously exhausted at 1100° before the mineral was introduced.

The lime used was intended to stop sulfur, halogens, and phosphorus, but at the temperature of evacuation would not hold CO_2 nor H_2O. At the close of the run there was no evidence of carbon deposited in the lime as one might have expected had there been heavy hydrocarbons or tar present, nor did any such deposit appear when the lime was later dissolved for analysis. This fact combined with the results from the combustion indicates the absence of heavy hydrocarbons.

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[6] The Analysis of Gases Obtained from Volcanoes and from Rocks, E. S. Shepherd, *Journal of Geology*, Vol. **XXXIII**. Supplement to Number 3, 1925 (H. V. E.).

Temperature of Evacuation 1000–1100°C., time about 20 hours.

Material taken	0.3310	Ash $=3.48$ per cent.
After	0.1909	Carbon (by difference) $=54.20$ per cent.
Loss	0.1401 or 42.3 per cent.	
Weight of volatiles recovered	0.1395 or 42.1 per cent.*	

* Note. The agreement implies an unusual series of compensating errors since the methods claim no such precision.

Total volume of "fixed gases" at 0°, 760 mm. = 173.4 cc.
Total volume volatiles at 1200°, 760 mm. = 1016.5 cc.

Volume per cent at 1200°, 760 mm.

CO_2	6.444
CO	35.827
CH_4	1.500
H_2	44.498
N_2	3.562
A	0.010
S_2	0.063
Cl_2	0.033
F_2	0.167
H_2O	7.857

cc/gm = 3071

All rare gases are lumped as argon because there was too little to justify an attempt to separate them. The value $A/A+N$ x 100 $=1.5$ is but little above the argon ratio for atmospheric nitrogen.

Phosphorus was detectable in the lime but not enough to bother with.

H_2O was 3.59 per cent by weight, thus lower than obtained by Ellsworth, but the total volatiles runs much higher. From the nature of the material no very definite ratio was to be expected. The ash varies greatly in color. Some pieces are white and some green, indicating irregular distribution of metallic oxides."

Geophysical Laboratory,
May 2nd, 1927.

E. S. Shepherd.

The great discrepancies in regard to ash, gas and H_2O content between Dr. Shepherd's results and the writer's can only be explained by supposing that specimens of thucholite from different parts of the dike vary greatly in quantitative composition. The specimens examined by the writer had been derived mainly from one particular small area of the dike and evidently all had much the same composition. Since the time of the writer's work, however, various additional specimens were assembled in one tray along with what was left of the original lot. The lot sent Dr. Shepherd later on was thus taken at random from a mixed assemblage representing more widely separated parts of the dike. The differences in our results apparently mean simply that thucholite is not nearly so constant in quantitative composition over the whole dike as was indicated by the writer's results for specimens from a small restricted area. In another paper[7] it will be seen that not only the amount of ash but also its percentage composition is quite variable, though the same constituents are present in both cases.

The work of Dr. Shepherd adds much to the interest of this remarkable mineral. It was surprising enough to find a carbon containing 25 to 28 per cent of rare element compounds and yet yielding no visible evidence of their presence, but when in addition to this we find an enormous gas content in which hydrocarbons are practically absent, one cannot but feel that we have in thucholite a priceless scientific key mineral, which if carefully studied might yield important new information in the fields of both chemistry and geology. A full discussion of the possible significance of thucholite would occupy too much space here but a few important points might be briefly noted. The occurrence of carbon as a magmatic mineral is established, and it looks as if we have absorbed in thucholite a sample, preserved through some 1000 million years, of the final gases of a Precambrian granite magma, with the exception of helium which is not appreciably retained by carbon. It becomes evident also that uraninite is formed under strongly reducing conditions in the presence of carbon, carbon monoxide, and hydrogen and therefore we can be practically sure of its essentially UO_2 initial composition. The foundation for the autoxidation process in uraninite, as suggested by the writer thus becomes secure. Further, one might speculate as to whether the noteworthy differences between uraninite, which occurs in crystals, and the always amorphous pitchblende, may not be due to differences in the reducing effect of the magmatic vapors or solutions at the time they were formed.

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[7] Thucholite and Uraninite from the Wallingford mine, near Buckingham, Quebec. This Journal, following article.

Under highly reducing conditions such as prevailed when thucholite was formed uranium would appear as the lowest oxide (UO_2) which has a strong tendency to crystallize, so much so that artifical crystals can be easily prepared. Isomorphous oxides as ThO_2 (which is definitely known to be isomorphous with UO_2) and rare earth oxides (about which less is known at present) would be likely, if present, to crystallize with the UO_2 as uraninite. On the other hand, under less completely reducing conditions and probably at lower temperatures representing a later stage of the magmatic vapors, uranium would probably precipitate as U_3O_8 with which ThO_2 and rare earths are not isomorphous, and which has little if any tendency to crystallize. Thus we have a rather plausible explanation for the remarkable fact that uraninite always contains thorium and rare earths besides relatively large amounts of UO_2, often greatly exceeding the ratio of UO_2 in U_3O_8, and is always crystallized, whereas pitchblende contains only traces, if any, of thorium and rare earths and has a UO_2 content not greater in amount than is required for U_3O_8 and is never crystallized. The fact that carbon occurs in various forms in nickel-iron meteorites, as diamond in the blue ground pipes, etc., is sufficient evidence that it can be a primary constituent of deep seated rocks. In the case of the Parry Sound thucholite there seems to be little or no immediate ground for suspicion that the carbon may have come from limestones assimilated by the magma, the time-worn explanation usually advanced for all occurrences of calcite, graphite or other carbonaceous materials in igneous rocks, but unfortunately it cannot be said that the possibility of a limestone origin can be entirely ignored even here. There is comparatively little limestone in the Precambrian region bordering Georgian Bay and none in the immediate vicinty of the thucholite occurrence so far as the writer is aware, the nearest outcrop seen being a band perhaps a 100 ft. wide which crosses the junction of the concession road between McKellar and McDougall township and the road leading to McKellar and Dunchurch, about 16 miles from the thucholite dike. This band seems to strike about N25° east magnetic and probably continues with increasing volume through Limestone Lake, Fairholme P. O. and past Dunchurch. The strike of this band apparently would carry it no closer than about 10 or 12 miles NW of the thucholite locality. The absence of contact pyroxenites (consisting largely of sahlite and calcite) formed by the action of granite on limestone, which are so characteristic of regions such as the Gatineau and Lièvre river, where limestone is abundant, is further evidence that such action has not occurred in the neighborhood of the thucholite dike.

During the present year the writer performed some further experiments on thucholite. It was thought for one thing, that possibly lead had been lost by volatilization during the combustion of the mineral, and that perhaps a greater percentage could be obtained by acid extraction. As material a single nodule was selected, which for apparent purity and homogeneity was the best of the whole collection. This was a solid nodule showing under the binocular only a few very small patches of decomposed cyrtolite intergrowth confined to the outer surface. The cyrtolite was cut away and the outer surface filed until no further impurities could be seen. The nodule was then broken into fragments and about 0.4 g. of apparently pure fragments were selected. Of this 0.1100 g. was burned in a platinum crucible yielding 0.0243 g. of ash equal to 22.09 per cent. The remainder, 0.3065 g. in weight, was leached with acids and the acid extract with the washings evaporated in a small platinum dish, ignited to oxide and weighed, the extracts of chlorides of course being first converted to nitrates before ignition.

		Grams
Extracted by H_2O only	3 hrs. on hot water bath	0.0005
“ “ 10% HCl	3 “ “ “ “ “	0.0289
“ “ 10 “ “	3 “ “ “ “ “	0.0087
“ “ 10 “ “	6 “ “ “ “ “	0.0072
“ “ 35 “ “	16 “ “ “ “ “	0.0068
“ “ *HF. H_2SO_4 and final 35 per cent HCl		0.0088
		0.0609

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* This extraction was first by HF only, followed by 3 hours with concentrated H_2SO_4 at the fuming temperature, and after washing by final treatment with 35 per cent HCl overnight on hot water bath, followed by a long treatment with hot water. All these separate extracts being small were combined and the total weighed 0.0088 as oxides. The long treatment with hot concentrated H_2SO_4 attacked the mineral somewhat, the acid becoming dark brown and on evaporation a small amount of a yellowish organic compound appeared in the dish.

It had been observed in the earlier work that there was a slight amount of water soluble substance. Microchemical and spectroscopic tests indicated that the water soluble material is mainly sulfate and chloride of sodium. A Nessler's test for ammonia gave positive indications also, but the ammonia may have come from the laboratory air or water.

The appearance of the thucholite fragments viewed under the binocular microscope was not noticeably changed after the severe acid treatment, except that some pieces developed ordinary fractures due to internal strain, and in some fragments very minute fissures, apparently resulting from solution, were visible. It has been mentioned previously that a polished surface examined by reflected light appeared to be entirely homogeneous except for the presence of a few very minute lines of harder material standing in relief. The solution fissures just mentioned have exactly the appearance that would result if these lines of harder material had been dissolved out. Otherwise the leached grains seemed to have retained their original brilliant lustre.

The specific gravity of the acid leached thucholite dried at 120° was determined after thorough boiling in a silica pyknometer, to be 1.75. This value which is nearly that (1.777) obtained on the unleached material of the earlier experiments is perhaps due to the leached mineral being more readily penetrated by water.

The oxides obtained by acid leaching amount to 90.09 per cent of the total obtained by combustion, and as probably much of the silica was retained by the carbon and volatilized by the HF treatment, it was concluded that the extraction was nearly complete. A 0.0969 gram portion of the original material dried at 120° was brought to a red heat in a covered platinum crucible, not more than one minute being required, and the material on weighing was found to have lost 0.0338 gram, so that there appears to be about 30 per cent of volatile matter present. About 15 minutes ignition with the crucible open in a large Meker flame was required to burn the remainder. The ash remaining weighed 0.0004 g. or about 4 per cent. Thus it appears probable that the ash could be entirely removed by acid leaching if the material were ground fine and given a sufficiently prolonged treatment.

The 0.0604 gram of extracted oxides were united and as a certain amount of silica had been extracted along with the other substances, this was removed by HF and H_2SO_4. A few of the main constituents were then determined with minimum results for the carefully purified oxides as follows:

	Grams	Per Cent
PbO	0.0002	0.3
CaO	0.0018	3
ThO_2	0.0224	37
R.E.	0.0087	14
*ThO_2+R.E.	0.0025	4

* Slightly impure recoveries not further treated.

There was a comparatively large amount of uranium present but owing to an accident it could not be determined. V, P_2O_5, Fe, etc., were present as usual. This analysis confirms the suspicion that the CaO of the earlier more complete analysis was low. No more lead was obtained than in the first analysis. Nickel and cobalt were sought in the 0.0243 of ash from the combustion of this lot, but no trace of either was found.

When the author in 1921 first identified the mineral here referred to as thucholite he was inclined to regard it with some justification as something entirely new and unheard of. As a matter of fact there appears to be no reference to any such mineral in the recognized works on mineralogy, though as it subsequently turned out this mineral had been found and superficially described long ago in both Sweden and Canada. A chance reference led to the following article in *Comptes Rendus*, Vol. **CXVI–1893**, pp. 677–678, entitled Extrait d'une Lettre de M. Nordenskiöld à M. Daubrée. After some remarks on the occurrence of diamond the writer continues:

> Ne rencontrez-vous pas des bitumes ou de l'asphalte dans les roches cristallines? Comme vous savez, nous en trouvons des masses assez considérables en Suède, dans nos mines de fer, surtout dans celles des environs de Norberg et de Dannemora. Il existe deux types tout à fait différents de ces bitumes:
>
> (a) Bitumes donnant beaucoup de produits à la distillation et ne laissant après leur combustion presque point de cendres:
>
> (b) Bitumes ressemblant à l'anthracite, n'abandonnant à la distillation que des quantités insignifiantes et laissant un poids assez notable de cendres. J'ai analysé la cendre des bitumes anthracitiques et j'ai trouve qu'elle contient toujours, outre silice, fer, chaux, magnésie, etc., plusieurs parties pour 100 des oxydes de nickel d'urane (3 pour 100), des terres de la cérite et de la gadolinite. Ces mêmes oxydes, jusqu'à present réputés si rares, se trouvent aussi dans la cendre d'une espèce de charbon formant de grands nodules dans nos plus anciennes couches sédimentaires (schiste à alun), ainsi que dans la grahamite de l'Amérique du Nord.

> L'association dans les minéraux asphaltiques, de la matiére charboneuse avec le nickel, l'uranium, le cérium, l'yttrium, etc., me semble fournir une indication: d'une part, sur l'origine des substances bitumineuses dans nos roches cristallines et nos plus anciens schistes sédimentaires, que seraient dues à des emanations de l'interieur du globe; d'autre part, sur l'existence de combinaisons de l'oxyde de carbone avec l'uranium, l'yttrium, le cérium, etc., analoques au nickel carbonyl.

There can be little doubt that the material referred to by Nordenskiöld as "bitume (b)" was identical with thucholite. As a matter of fact, Nordenskiöld's statement as to the occurrence of the two kinds applies equally well to Canada. The writer has collected specimens which are almost like tar, rich in heavy hydrocarbons and which can be melted and ignited with a match but contain little or no rare element compounds. These also came from granite pegmatite, but the two varieties have not so far been found together in the same dike and it appears advisable to consider them entirely distinct minerals as they are quite different in composition and physical properties.

The mineral was apparently first discovered in Canada about 1894. In the *Journal of the Canadian Mining Institute*, Vol. **VII**, 1904, we find a paper entitled "On a Mineral Containing 'Radium' in the Province of Quebec" by J. Obalski, Inspector of Mines, Quebec. This short but interesting paper is reproduced in full below, the photographs and discussion only being omitted.

> Since the new element, "radium" has been discovered, much attention has been called to the minerals containing it; so far it appears that the uranium ores are the only ones in which it has been found.
>
> In our Laurentian formations, uraninite, composed of oxide of uranium and other rare metals, has been met with in some pegmatite dikes, which have been operated as producers of white mica (muscovite), and we have the records of the Villeneuve mine in Ottawa county, with monazite and uraninite, and of the Maisonneuve mine, in the county of Berthier, with samarskite; we have also several other white mica mines and prospects in the Saguenay district, but so far uranium ores from these have not been noted.
>
> About ten years ago I found in a mine of the Saguenay district, then operated by the "Canadian Mica Co.," a remarkable specimen which I identified as "cleveite," and which is shown in the accompanying photograph.
>
> This specimen has a specific gravity of 8.43, and weighs 375 grammes, or about 13 ounces. It is well crystallized in a dodecahedron form, deriving then from the isometric system. A complete analysis has not yet been made, but it contains 70.71 per cent of uranium oxide.
>
> Radium having been discovered and found to exist mostly in connection with uranium ore, I experimented with the above mentioned crystal, and found it affected strongly the photographic plates, as shown by the accompanying radiographies.

The specimen has also a well marked action on the electroscope. I came then to the conclusion that it contained radium, and to have my opinion confirmed, I showed the specimen to Professor Rutherford, of McGill University, who, after testing it, stated that its radio-activity was equal to four or five times the activity the crystal would have if it was entirely composed of uranium and that it contained one-tenth of a milligram of radium, making it comparable with the best pitchblende so far operated for the production of radium. This crystal may be an accidental one, although I have found other small pieces of the same mineral in this vein, but I have also found in the same a carbonaceous material burning quite easily, and leaving ashes containing oxide of uranium. The specimens of the above coal have been tested by Mr. Milton L. Hersey, of Montreal, with the following results:

This "coal" has a fibrous, irregular structure, and contains a small amount of mica; it proved to be of a similar nature to a non-coking bituminous coal, yielding considerable gas, which burned with a bright yellow flame.

Volatile matter (including volatile combustible matter and a small quantity of moisture)	40.185
Fixed Carbon	52.590
Ash	7.225
	100.000

The ash itself was analyzed and found to contain 2.56 per cent of uranium, based on the coal, which is equal to 35.43 per cent of uranium in the ash itself.

It is important to note that the color of the ash was olive green, being due to the presence of oxide of uranium.

In another test, the coal was not burnt, but was merely finely pulverized and the powdered coal treated with boiling nitric acid, to dissolve the uranium compounds. It is then interesting to note that the uranium may be extracted by the direct treatment of the coal with nitric acid. A sample of this "coal" from the same place, tested in Montreal, was found to be radio-active as well as the ashes it gave; this radio-activity being due to radium.

I am not able to state what is the relation between the two specimens of cleveite and "coal" but I think this fact important, and I propose to make a further investigation next summer.

The white mica vein where these specimens come from is situated near the lake "Pied des Monts" about 18 miles back of Murray Bay, in the county of Charlevoix, on the north shore of the St. Lawrence.*

In spite of the meager chemical data for the Murray Bay mineral, it is quite evident that the material was very closely related to the Parry Sound mineral though apparently the former contained appreciable hydrocarbons which the latter does not.

* Note.—Since the above notes were read at the meeting, I had a letter from Mr. P. Curie, of Paris, in which he says that the small piece of cleveite from Murray Bay, I sent him, shows a radio-activity equal to six times the one of uranium, and he wants to be kept well posted about the new discoveries of radio-active minerals, in Canada.

One can be almost sure that the Murray Bay specimen contained vanadium, just as does the Parry Sound mineral, from the statement that the ash was colored olive green, this green color being due to vanadium rather than to uranium as stated, and there can be little doubt that the ash also carried thorium, rare earths, etc., like the Parry Sound and other examples. The similarity of the two occurrences is noteworthy. Both occur with uraninite in coarse granite pegmatites characterized by large muscovite crystals. The writer visited the Pied de Mont mine but it had been long abandoned and not the slightest trace of either uraninite or thucholite could be found. Nor was it possible to find any of Obalski's original material at Quebec. It is thought that he probably sent over most of his rare mineral finds to the Curies.

Thanks to the interest of friends among the mining men and by personal collecting the writer has secured specimens of carbon minerals from quite a number of Canadian localities. Of these some are tarry but three have been examined sufficiently to identify them as thucholite, so that including Obalski's Pied de Mont mineral we have at least four known occurrences, all in widely separated granite pegmatites of the Precambrian shield. Considering how seldom it is that pegmatite workings are visited by mineralogists or others likely to recognize this mineral and the brief periods of such visits when they do occur, it seems likely that substances such as thucholite and the tarry hydrocarbons are by no means rare in them, and that carbon as a constituent of igneous magmas is a much more important and frequently occurring element (if indeed in reality it does not always occur) than has been commonly supposed. The writer has in the past referred to this substance as a "mineral resembling anthraxolite," etc., which is true in regard to its appearance only, but as it is absolutely different from anthraxolite both in composition and origin, it seemed desirable to give it a distinctive name. Anthraxolite was the name first applied by E. J. Chapman[8] to a substance from Lake Superior having the following composition:

Moisture	2.08
Volatiles	3.56
Fixed carbon	94.36
Ash	0.00
	100.00

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[8] *Canadian Journal*, Vol. X, p. 410, as quoted by Ellis.

This was said to occur in a banded vein with quartz and pyrite.

The substance which has come to be accepted as the type anthraxolite, however, is the well known hard carbon of the Sudbury basin near Chelmsford, Ont., which is periodically rediscovered and put forward by promoters as anthracite coal. The writer has examined this mineral carefully both in the field and in the laboratory. Along with much quartz and pyrite it occurs as intrusive masses, pegmatite-like in form and sometimes of considerable size, cutting carbonaceous slates. The anthraxolite itself is almost pure carbon but it is much fractured and all the cracks, even the most minute, are filled with quartz along with, usually, a considerable amount of pyrite. It is scarcely possible to find a piece as large as an inch square, at most, which is not penetrated by quartz visible to the naked eye and the purest pieces when carefully burned in a crucible leave delicate films of silica where quartz had evidently been present as extremely thin veinlets. Apart from pyrite there is only the most minute amount of true ash actually belonging to the carbon itself, probably not more than a few hundredths of one per cent, and this appears to be chiefly iron. Tests for combustible volatile constituents and for heavy hydrocarbons gave negative results. Some analyses made long ago by Prof. W. H. Ellis[9] of the University of Toronto, are produced below:

"Proximate Analysis of a Selected Sample of Sudbury Anthraxolite" by W. H. Ellis.

Moisture	4.0
Volatiles	1.8
Fixed Carbon	90.1
Ash	4.1
	100.0

"Ultimate Analysis of a Carefully Picked Specimen (of Sudbury Anthraxolite) freed from Moisture" by W. H. Ellis.

Carbon	94.92
Hydrogen	0.52
Nitrogen	1.04
Sulphur	0.31
Oxygen	1.69
Ash	1.52
	100.00

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[9] Analysis of some Pre-Carboniferous Coals, *Chemical News*, Oct. 15, 1897, pp. 186–188.

Ellis notes that the ash consists of silica and iron. Refined methods of gas analysis such as developed by Shepherd of course were not in use at the time of Ellis' work, but the analyses serve to show that there is not much volatile matter in anthraxolite.

The Sudbury mineral has always been considered to have originated from the distillation of the carbonaceous slates as a result of the intrusion of the Sudbury nickel eruptive. Thus it differs from thucholite in both composition and origin.

As there appears to be no suitable name in English for the carbon material described here the writer ventures to suggest the name thucholite as more or less appropriate, besides being easy to pronounce and to remember. The word consists simply of the chemical symbols of some of the main constituents with the letter "l" added for euphony, and the usual mineralogical ending "ite." The pronounciation suggested is thū′-chō-lite.

The writer wishes to thank Dr. A. L. Day, Director of the Geophysical Laboratory, Washington, and Dr. E. S. Shepherd of that institution, for the work of the latter on thucholite, also Mr. J. McLeish, Director of the Mines Branch, Department of Mines, Ottawa, for the use of apparatus and laboratory facilities of that branch.

Since the above article was written I have received (March 1928) from Prof. A. Fersman of Leningrad a communication informing me of the occurrence of thucholite in Russian pegmatites. The Russian mineral is described in a paper[10] entitled "Mineralogy of Northern Karelii," very kindly sent me by Prof. Fersman.

A translation (from the Russian) of the portion of the paper describing the thucholite was very kindly made by A. Anrep, Geological Survey, Ottawa, and is as follows:

CARBON-URANIUM MINERAL

A carbonaceous uranium-bearing mineral of considerable scientific interest is found in certain veins both with uraninite and without it. The mineral is of black color, very friable and light (or soft) and is composed of grains ranging from 0.1 to 2 cm. in diameter embedded in quartz. Around these imbedded pieces as well as around the uranium are detected evidences of radium emanations; the periphery of the grains have short projections.

Experimentation by K. A. Nenadskevich showed that the mineral burnt easily and leaves an ash content of 9.5 per cent when heated in a closed tube. There is separation of water along with a slight amount of ammonia and a slight trace of sulphur.

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[10] A. H. Labunzof, *Bulletin de l'Academie des Sciences de l'Urss,* **1927,** p. 617.

The content of carbon is around 60 per cent. Moisture loss on drying at 100° 9.7 per cent and above 100° 19.3 per cent; 0.01 per cent NH_3 and H_2SO_4. The ash (9.5 per cent) contains UO_3 54.20; PbO 17 per cent and Fe_2O_3 6 per cent.

This type of mineral with a decidedly magmatic origin is of great scientific interest as it shows that uranium does occur in certain kinds of carbonaceous particles.

Similar occurrences of carbonaceous uranium-bearing minerals are mentioned by Obalski of the Department of Mines, Province of Quebec, who states that in the pegmatite veins of Quebec as well as in the clayey wall-rock are to be found small carbonaceous grains, which after being burnt leave a residue of 7 per cent ash, containing 35 per cent UO_3.

In an earlier part of the paper it appears that the author describes some 87 pegmatite dikes occurring in the district situated on both sides of the Murmanskoy railway from Kovda station on the north to Engozero station on the south. The district is about 100 miles long by 80 miles wide and is an eastern continuation of the Finnish mountain region which towards the east terminates near Kandalaschskii bay of the White sea.

Prof. Fersman states that further chemical investigations on the mineral are being carried on by Messrs. Nenadskevich and Wernadsky. H.V.E.

II. CYRTOLITE INTERGROWTH ASSOCIATED WITH THE PARRY SOUND THUCHOLITE

As was noted in (I) the Parry Sound thucholite nodules almost invariably carry on their outer surfaces more or less embedded or intergrown cyrtolite. This is generally without definite crystal form but occasionally shows a development of the typical zircon-like square prisms with curved faces characteristic of cyrtolite. (Fig. 3). Usually also it is considerably altered. No detailed optical study of the mineral was made, but it was seen that there are at least three substances present, viz., the zircon-like prisms, a massive material which is more altered than the crystals, and minute inclusions of thucholite. Most of the grains had n greater than 1.75 but some were lower. All grains had indices greater than 1.65. From the analysis it appears that the constituent with the lower index is probably a phosphate which may be closely related to, or identical with, the material mentioned in (I) as being possibly a new silico-phosphate of calcium and the yttrium earths.

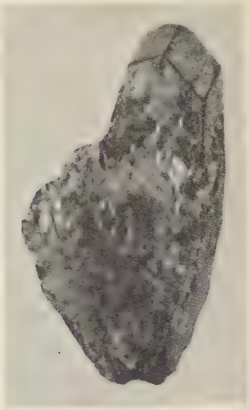

Fig. 3. Cyrtolite mass showing typical radiating structure at base and crude zircon-like crystal at top. Actual size about 1 cm. in longest direction.

Some typical examples of the cyrtolite intergrowth were selected and ground for analysis. A little thucholite was unavoidably present in the sample analyzed but not enough to appreciably affect the results, which are given below:

Analysis of Cyrtolite Intergrowth Associated with the Parry Sound Thucholite.

[1]ZrO_2	43.03
U_3O_8	1.46
ThO_2	0.66
PbO	Not det. accurately
$(Ce, La, Di)_2O_3$	0.34
$(Yt, Er)_2O_3$	6.76
Fe_2O_3	4.16
Al_2O_3, etc.	3.12
MnO	0.02
TiO_2	0.06
V_2O_5	Not detected
CaO	1.58
MgO	0.18
SiO_2	22.86
P_2O_5	3.53
Loss at 110°	1.64
[2]Loss above 110°	10.90
	100.30

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[1] Probably includes an appreciable amount of hafnium. The precipitation was by cupferron.

[2] Includes traces of carbon from thucholite.

Minerals such as cyrtolite and alvite (which apparently are much the same thing if not identical) have taken on new interest and importance as the richest source of element 72-hafnium. According to D. Coster and G. von Hevesy and associates the presence of considerable quantities of hafnium seems definitely to be directly related to an appreciable content of uranium, rare earths, etc. It is noteworthy also that zircons which are not altered contain very little hafnium and little or no uranium, rare earths, etc., while the cyrtolite group of minerals containing these elements are always considerably altered.

Cyrtolite is quite often found in Ontario pegmatites as nodules of crude crystal aggregates, sometimes as large as a fist or larger.

THUCHOLITE AND URANINITE FROM THE WALLINGFORD MINE NEAR BUCKINGHAM, QUEBEC

H. V. ELLSWORTH,* *Canada Geological Survey.*

Thucholite from Parry Sound has been described in an earlier paper.[1] Thanks to the interest of Mr. N. B. Davis, consulting mining engineer of Ottawa, who has been in charge of development at the Wallingford feldspar mine, both thucholite and uraninite have been found in small quantity in this mine also. The finding of these minerals gives point to a statement once made by the writer in which the belief was expressd that if competent observers were available to watch the workings it would probably be found that radioactive minerals occur much more frequently in pegmatites than is generally supposed. The casual visitor to the Wallingford at the present time would be very fortunate indeed if he found a single specimen of either mineral, even though he knew they occurred there and looked particularly for them.

The Wallingford mine is on lot 14, range II of Derry Township, Ottawa County. It is reached by a mine road from the Derry feldspar mine which itself is connected to the main Lièvre river highway by a road over which automobiles can be driven. This is an old mining region noted long ago for its production of apatite and mica, and more recently for its high grade feldspar.

The pegmatite of the Wallingford is a large dike of varying width which it is said can be traced for a mile or more in a north-west south-east direction. Mr. Davis states that the narrower parts consist largely of the usual graphic intergrowth of quartz and microcline with occasional patches of coarse crystal microcline and massive quartz in some of the wider swellings, and further that at the south-east end it becomes narrow and joins or appears to be an offshoot from a large dike of graphic granite perhaps 150 or more feet wide which strikes in a general north-east direction. At the Wallingford mine the dike outcrops for 100 feet or more over the face of a hill, dipping south-west, the actual width being possibly 75 feet. It consists of great masses of white quartz comprising, so far as at present explored, perhaps two thirds of the whole, the remainder being chiefly a very light colored, in places pure white, microcline containing a small amount of plagioclase as a fine perthitic intergrowth. The mine is worked from a tunnel and also by open cutting at the top of the hill. Both quartz and feldspar are mined and sold, the proportion of quartz being so great that probably the feldspar by itself could not be profitably won. Besides the microcline and the huge masses of white quartz there are patches, as much as several feet in diameter, of greenish gray plagioclase feldspar, in which small masses or veins of pyrite and pyrrhotite an inch or so wide sometimes occur. Masses of granular, dark, smoky quartz several feet in diameter are also present. Thin dentritic crystal growths of black tourmaline are quite often seen and more rarely crystals up to an inch diameter may be found. At one place in the open cut on top there were bodies several feet long of a streaky looking dull grayish black material which qualitative tests indicate to be allanite. This allanite has a peculiar appearance which the writer has never previously seen in connection with this mineral. It shows nowhere the slightest indication of crystal outlines, contains long narrow streaks of plagioclase feldspar, and in general has a coarse fibrous structure parallel to the long direction of the bodies, giving the impression that the structure may have been produced by shearing, or rather by plastic deformation during the crystallization of the mineral. Some of these streaks of allanite have superficially the appearance of veins an inch or more wide and several feet long cutting the feldspar, but on closer examination it is seen that these "veins" have a fibrous structure parallel to the long direction, with included long narrow streaks of plagioclase and in short, every appearance of having been produced mechanically. The allanite is quite radioactive and contains an unusually high percentage of thorium so that it will be possible to make an interesting comparison of the lead ratios of the two minerals. Nodules of both uraninite and thucholite, up to one quarter inch diameter have been found but unfortunately both are usually much altered, the uraninite to yellow gummite so called, the thucholite to a powdery black substance. Even the best specimens of uraninite so far obtained are more or less altered and only small amounts have been secured, so that it has not yet been possible to make an analysis of the highest accuracy using 2 gram portions, as has been done in the case of other Canadian uraninites. At one time a patch 3×6 feet in area, chiefly microcline, was exposed, which was quite abundantly encrusted with a thin coating of yellowish green uranium (and vanadium?) decomposition products. Within this area were quite a number of nodules of gummite from a millimeter to a quarter inch in diameter and some blackish specks probably representing decomposed uraninite-thucholite intergrowth. Thucolite occurs in various forms in microcline, quartz or plagioclase. Much of it is powdery and dead looking but some retains its original brilliant black lustre exactly resembling the Parry Sound mineral, the description of which applies to this also. Most often it is in rounded grains but it also occurs intergrown with altered uraninite or possibly partly replacing the latter as cubes and octahedrons (Fig. 1) about 5 mm. in diameter. These crystals have a coating of more or less lustrous thucholite next the matrix with altered uraninite inside. A typical example of the cubic form was extracted from the rock and analyzed with results as on page 447. One specimen, the largest and most interesting of all (Fig. 2) is a pseudomorph after tourmaline. So perfectly are some of the faces (*a* and *m*) of the original tourmaline preserved that they could be accurately measured and identified by means of a contact goniometer. The thucholite of this unique tourmaline pseudomorph fortunately is fairly well preserved, solid and brilliant in lustre. Associated with the thucholite in the pseudomorph is

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[1] This Journal, preceding article.

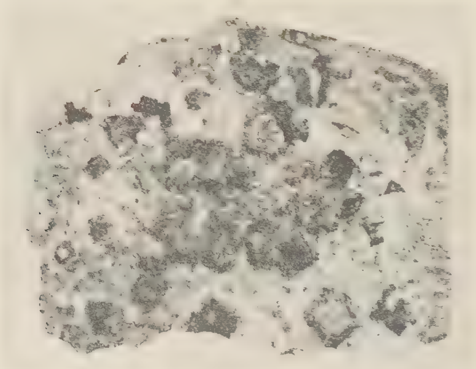

Fig. 1. Photograph showing crude cubic and octahedral crystals of altered uraninite enclosed in darker thucholite.

quite a little pyrite and some soft whitish substances not yet exactly identified, but evidently sulfate decomposition products, which are probably new minerals.

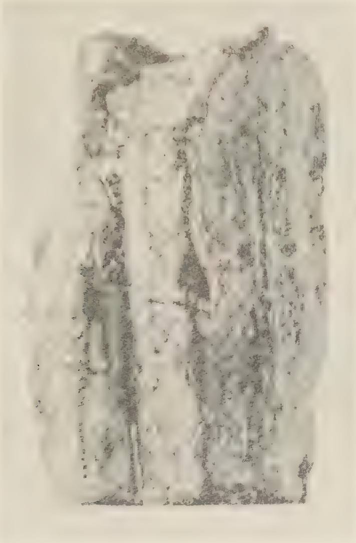

Fig. 2. Pseudomorph of thucholite after tourmaline. About twice natural size Faces *a* and *m* in front are quite sharp and measurable. The photograph does not do justice to the specimen.

A small crystal of zircon or more probably cyrtolite can be seen embedded in the pseudomorph and similar small crystals or crystal aggregates of this mineral can usually be found in the rock close to or touching thucholite nodules.

The similarity of the Parry Sound and Wallingford thucholite occurrences is evident. At both places thucholite, uraninite and cyrtolite occur in close association. At the Wallingford, however, though some of the thucholite apparently was formed at the same time as uraninite, there is evidence of considerable late pneumatolytic activity in the replacement of tourmaline and possibly uraninite by thucholite, whereas at Parry Sound thucholite seems to be entirely contemporaneous with uraninite.

The thucholite for analysis was from nodules of the best preserved materials carefully examined under the bincular microscope. The small amount of good material obtained did not yield sufficient ash to permit making a complete analysis. Results were as follows:

ANALYSIS OF 0.1411 GRAM THUCHOLITE FROM THE WALLINGFORD MINE.

	Grams	Per Cent
Loss in 3 days over conc. H_2SO_4	0.0122	8.64
Loss in 3 hrs. at 110°	0.0069	4.89
Loss in 1 minute at red heat in covered Pt. crucible, CO_2 passing	0.0405	28.70
Residue after combustion	0.0280	19.84
	0.0876	62.07

Hence, approximately:

	Per Cent
H_2O	13.53
Gases	28.70
Ash	19.84
Fixed Carbon	37.93
Heavy Hydrocarbons	Not detected
	100.00

From the 0.0280 g. ash the following minimum amounts of pure substances were obtained:

	Grams	Per Cent
PbO	Undeterminable	
U_3O_8	0.0051	18.2
ThO_2	0.0029	10.4
$(Ce, La, Di)_2O_3$	0.0064	22.8
$(Yt, Er)_2O_3$	0.0036	12.8
CaO	0.0044	15.7
Fe_2O_3 Al_2O_3 etc.	0.0012	4.3
SiO_2	0.0018	6.4
P_2O_5	Present—Not determined	
	0.0254	90.6

The analytical examination suffices to show the resemblance of this mineral to the Parry Sound thucholite. The variations in composition of the mineral from the two localities are probably no greater than the differences between individual nodules from either locality.

The Wallingford thucholite is particularly interesting because it not only is intimately associated with uraninite, but it actually replaces tourmaline showing that it is not confined to relatively high temperature conditions but can also be produced by late pneumatolytic action. Thus it appears that carbon must be included with boron, fluorine, sulfur, water, etc., as one of the constituents of the residual solutions of granite magmas.

ANALYSIS OF URANINITE-THUCHOLITE CRYSTAL FROM THE WALLINGFORD MINE

A typical crystal as seen in Fig. 1 was extracted and analyzed with results as follows:

Wt. of substance	0.1328 g.
Loss on ignition	0.0115 g.

Thucholite+H_2O, He, etc. = 8.66 per cent approx.

Allowing for water present there probably is not more than 6 or 7 per cent thucholite by weight in this specimen though others might have been selected which would show considerably more.

On heating the black ignited material with HNO_3 it behaved exactly like uraninite, dissolving with effervescence accompanied by evolution of red nitrous fumes and the production of a strongly yellow colored solution. A certain amount of reddish colored material, probably thorium and cerium oxides remained undissolved however, so the whole was heated for several hours with H_2SO_4, after which treatment everything appeared to dissolve except silica, etc., and lead sulfate. A careful analysis was then carried out with results as follows:

	Per Cent
PbO	9.88
(Pb = 9.17)	
U_3O_8	68.92
(U = 58.46)	
ThO_2	6.76
(Th = 5.94 × 0.38 = 2.26U equivalent)	
$(Ce, La, Di)_2O_3$	0.66
$(Yt, Er)_2O_3$	4.04
Fe_2O_3 Al_2O_3 MnO	2.55
CaO	0.93
SiO_2	3.46
	97.20

$$\frac{Pb}{U+0.38\ Th}=0.151$$

A certain amount of decomposed feldspathic and micaceous material from the matrix adhering to the uraninite-thucholite crystal doubtless accounts for the high alumina, iron and silica.

Though the amount of substance taken was small the percentages of Pb, U and Th are such that the results may be considered sufficiently accurate to demonstate that this uraninite agrees perfectly in its age indications with those of other Canadian uraninites examined by the writer.

ANALCITE FROM BREWSTER COUNTY, TEXAS

JOHN T. LONSDALE, *University of Texas.*

The specimens of analcite reported in this paper were secured from the dump of the abandoned quicksilver workings on Section 248, Block G4, in the Terlingua district, Brewster County, Texas. They are thought to be the first record of the mineral in Texas. The quicksilver workings were not accessible because of water but reliable information indicates that a body of analcite-bearing basalt was encountered at a depth of about 75 feet. The region is one in which Tertiary intrusive and extrusive igneous rocks are abundant. No analcite bearing rocks or related types have been found before this time but the igneous rocks are not well known and the discovery of additional occurrences will not be surprising.

The specimens of analcite found were light gray to white crystals ranging in size from 1 mm. to 6 mm., a number of which were coated with asphalt from a seep in the workings. The basalt containing the crystals was so extensively altered that they were readily removed. The alteration is of a type not seen in the igneous rocks found at the surface nearby and is possibly related to the mineralization that produced the quicksilver deposits.

Many of the analcite crystals were euhedral. The greater number of these showed a trapezohedron, probably (211) without other forms in combination. A few crystals showed the cube (001), in combination with the trapezohedron but only very slightly developed. The index of refraction was determined as 1.484, a somewhat lower value than commonly given for analcite but believed to be correct in this instance. All sections examined showed the slight birefringence frequently observed in this mineral.

A chemical analysis of the analcite, made in the Bureau of Industrial Chemistry, University of Texas, is given below.

SiO_2	56.53
Al_2O_3	21.61
Na_2O	9.95
K_2O	2.20
CaO	0.81
MgO	0.18
H_2O+	0.58
H_2O-	8.15
Insoluble in HCl	1.51
	101.52

The slight double refraction shown by the crystals is so uniformly present and regularly disposed that its anomalous character is questioned. The crystals are divided optically into sectors each of which is bisected by a crystallographic axis. The two sectors on opposite sides of the crystal behave similarly and in all sectors the vibration directions are parallel to the crystallographic axes. The vibration direction parallel to the crystal axis bisecting any given sector is always greater than the direction at right angles to the crystal axis. An indistinct biaxial interference figure was secured from some of the sections. Through the kindness of Professor A. N. Winchell an X-ray pattern of the mineral was made. According to Professor Winchell the analcite pattern does not correspond to an isometric structure but is not greatly different from one.

The analcite apparently is primary in the basalt. There is some suggestion from the crystal habit that analcite has replaced leucite and the extensive alteration already mentioned might account for such a change. However, in the absence of conclusive evidence the mineral is regarded as primary.

NOTES AND NEWS

STUDIES IN THE MICA GROUP (A DISCUSSION)

A. F. **Hallimond**, *Geological Survey and Museum, London.*

In a recent contribution to *The American Mineralogist* Professor Winchell[1] justifies his revised theory of the micas on the ground of the plausibility of a substitution in which the volume is unaltered, and concludes "the same theory [of Hallimond] . . . . is not in harmony with the modern analytical data on the composition of the micas of the muscovite series."

In their commonly accepted meaning the latter words appear to be incorrect. Reference to Professor Winchell's own diagram (*l.c.* p. 54) will show that the plotted data lie considerably nearer to the horizontal line required by my own theory than to the inclined line which he suggests. The mean difference of the potash values from my theory ($K_2O=100$) is $+1.1$ units, while the mean difference from the diminishing values required by Winchell's theory is no less than $+6.7$ units. These figures are directly at variance with the above statement by Winchell. The fact is that if the Kunitz analyses are to be brought into agreement with Winchell's theory the percentage of potash must be regarded as averaging about 0.7 per cent too high. This is a heavy correction, to which Winchell makes no reference whatever, though he has experienced similar difficulties in the earlier discussion of his theories. If 0.7 per cent is a fair estimate of the error possible in recent analyses we need look no further for a cause of the apparent deviations from the simple value $K_2O=100$. Any small real deviations that may underlie the published data will be completely submerged by the admitted experimental error.

In his amended theory Winchell adopts[2] my conclusion that in muscovite $RO+R_2O_3$ is constant. Even if, as he suggests, the substituent group is really $RO\cdot SiO_2$ instead of RO (and it is clear that the corresponding difference in composition hardly exceeds the limits of experimental error in analysis), there is still no difficulty in writing $RO\cdot SiO_2$ as a divalent group resembling "basic" Al_2O_3. The essential features of my theory (namely that the micas may be regarded as salts of hexa- (tri-) silicic acid with potassium and "basic" alumina as common bases) are not affected, indeed they have not yet been discussed at all by Winchell, though his original formulae have been withdrawn and others substituted embodying the replacement RO/R_2O_3.

Turning to the theoretical bases of Winchell's proposed formulae, the whole matter has been discussed by Wyckoff[3] who remarks "the results of crystal analysis do not, however, justify that extension of this idea which finds in this equality of interatomic distances the primary cause and principal determining factor of isomorphous atomic replacements." The need for a reasonable equality in molecular volume has long been a commonplace, though it must be widely interpreted to include eutropic replacements like K/Cs; but I do not think there is any escape from the necessity of expressing the peculiarities of the mica group by means of a chemical theory, as distinct from Winchell's successive proposals to base formulae on (1) equality in the total number of atoms, (2) equality in the number of oxygen atoms, and (3) equality of molecular volume.

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[1] *Am. Mineral.*, 1928, vol. **13**, p. 52.

[2] *Am. Mineral.*, 1927, vol. **12**, pp. 267–271.

[3] *Am. Mineral.*, 1923, vol. **8**, p. 90.

In conclusion I would enquire what is to become of lepidolite and the dark micas? In a revision of his lepidolite theory we found Winchell pleading[4] "Is it not possible that even in modern analyses the tenor of alkalis is actually a little too low." *Four out of the six analyses then under examination were by Kunitz, whose results we are now being asked to regard as about 0.7 per cent too high!*

The United States National Museum has acquired by purchase for the Roebling Collection a twin crystal of cerussite of exceptional size. It measures 12×9×4½ cm., and weighs 1½ kgs. The crystal is triangular in shape and is twinned on the prism *r* (130). It was found in the famous Tsumeb district of South-west Africa.

The next annual meeting of The Mineralogical Society of America will be held in New York City, in conjunction with that of the Geological Society of America and other affiliated Societies. The sessions will start Thursday and continue to Saturday, December 27–29, 1928. The American Association for the Advancement of Science will also meet in New York City at the same time. Sessions will be held at the American Museum of Natural History and at Columbia University.

Dr. Friedrich Becke, professor of mineralogy at the University of Vienna, has been elected a foreign member of the Swedish Academy of Sciences.

Professor Ludwig Milch, director of the Institute of Mineralogy and Petrology at the University of Breslau, died Jan. 5, at the age of 60 years.

The death has recently been announced of Dr. Julius Hirschwald, professor of mineralogy and geology in the University of Berlin, and of Professor Arthur Schoenflies, of the University of Frankfurt, the well known author of "Theorie der Kristallstruktur."

PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

Regular Monthly Meeting of March 21, 1928.

A regular monthly meeting of the New York Mineralogical Club was held in the Academy Room of the American Museum of Natural History on the evening of March 21, at 8:15 P.M. The president, Dr. Paul F. Kerr, presided, and there was an attendance of 42 members.

The Committee on Nominations submitted the following names for officers for the year 1928–29, to be voted on at the annual meeting on April 18th.

President: Herbert P. Whitlock.
Vice-President: Frederick I. Allen
Secretary: Howard R. Blank.
Treasurer: Gilman S. Stanton.

The President introduced the speaker of the evening, Dr. Waldemar T. Schaller of Washington, D. C., who addressed the Club on "*Borate Minerals from the*

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[4] *Am. Mineral.*, 1927, vol. **12**, p. 277.

Mojave Desert, California." Dr. Schaller before beginning his paper called the attention of the Club to some excellent specimens of a remarkable pink muscovite which was encountered in mining lepidolite in a pegmatite of northern New Mexico, and discussed its relation to the lepidolite.

Taking up his main theme, the borates of the Mojave desert, the speaker discussed the derivation of borate minerals in general, and enumerated the conditions under which boron-containing rocks break down, and how from the decomposed products borates are produced. In this connection he showed a number of slides illustrating a wide range of topographic conditions, and explained why a dry valley was necessary to the secondary deposition of borate minerals. The speaker then traced the history of borate mining in the southwest, dwelling particularly on the new commercial borates, kernite, mohavite and kramerite. He outlined the unsuccessful efforts which had been made to reproduce kernite in the laboratory, regarding which he stated that he had no explanation to offer.

In the discussion Mr. Shreve asked what mineral was the ultimate source of the boron. In reply Dr. Schaller mentioned volcanic fumeroles as being closely associated with boron emanations, and connected the fumerole minerals with the source of boron. He did not consider the tourmaline present in granitic rocks as occurring in sufficient quantity to produce borate deposits.

A rising vote of thanks was tendered to Dr. Schaller for his highly important and interesting address. The meeting adjourned at 9:35.

HERBERT P. WHITLOCK, *Secretary*

Regular Monthly Meeting of April 18, 1928.

A regular monthly meeting of the New York Mineralogical Club was held at the American Museum of Natural History on the evening of April 18, 1928. The president, Dr. Paul F. Kerr, presided, and there was a total attendance of 71 persons.

A motion was carried that the Club accept the invitation of Colonel William Boyce Thompson of Yonkers, N. Y., extended through Mr. Fred J. Pope, to visit his mineral and jade collection on the afternoon of Memorial Day, May 30th.

The following officers were elected for the year 1928–29:

President: Herbert P. Whitlock.
First Vice-President: Frederick I. Allen.
Second Vice-President: George E. Ashby.
Secretary: Horace R. Blank.
Treasurer: Gilman S. Stanton.

The newly elected president then assumed the chair and expressed his appreciation to the Club in a brief address.

The speaker of the evening, Mr. James G. Manchester, a member of the Club, was then introduced, and addressed the gathering on "*The Minerals of New York City and Vicinity.*" Under this head he included the territory within a 50-mile radius of the City. Noteworthy finds of minerals within the limits of Greater New York were first discussed, after which the speaker considered nearby counties of New York, Connecticut, and New Jersey. The talk was illustrated by lantern slides, and by many fine specimens, the fruits of 30 years of collecting by Mr. Manchester within the territory covered.

After a vote of thanks had been tendered to the speaker, a motion was carried that the Club publish Mr. Manchester's paper as soon as he is ready to present it in final form.

At the conclusion of the meeting some of the recently described minerals from Franklin, N. J., were exhibited by Mr. Hoadley, and a few hafnium minerals were shown by Mr. Lee.

HORACE R. BLANK, *Secretary*

Regular Monthly Meeting of May 16, 1928.

A regular monthly meeting of the New York Mineralogical Club was held at the American Museum of Natural History on the evening of May 16, 1928, with the president, Dr. Herbert P. Whitlock, in the chair. Forty-five members were present.

After a brief business meeting, Dr. Chester A. Reeds, curator of geology at the American Museum of Natural History, addressed the Club on "*Rivers That Flow Underground.*" Such subterranean streams are usually short and of small volume compared to surface rivers, and often appear at the surface as large springs. They are best developed in limestone regions, where they carve for themselves channels and caverns by solution of the rocks through which they flow. If elevation of the land takes place, the streams abandon their underground courses to seek new ones at still lower levels, leaving the former channels dry and open to exploration.

The speaker cited as examples underground rivers in the Endless Caverns, Va., Mammoth Cave, Ky., and others in France, Jugo-Slavia, and Greece. The lecture was illustrated with many lantern slides showing the formations encountered in the interior of caves, and by a number of specimens of stalactites and stalagmites.

The ensuing discussion led to the conclusion that the rate of deposition of calcium carbonate in cave formations was very variable under different conditions, but that in many known instances it was much more rapid than a frequently quoted rate of 1 inch per 2000 years.

After passing a vote of thanks to Dr. Reeds the meeting adjourned.

HORACE R. BLANK, *Secretary*

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, April 5, 1928.

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, with an attendance of thirty-one members and visitors. The president, Mr. Clay, presided. Mr. William Slimm was elected a junior member and Mr. Gordon nominated Mr. Herbert W. Brandeis and Dr. A. Bertram Gilliland for full membership.

Dr. A. C. Hawkins of Rutgers University addressed the meeting on "*Mineral Occurrences—New and Old.*" The speaker described a number of localities within seventy-five miles of Philadelphia, and especially the copper mines at Chimney Rocks, New Jersey, and the localities near New Brunswick which yield glauberite casts and calcite pseudomorphs in the red shales. This talk was illustrated by specimens and lantern slides and provoked considerable discussion at the close of the address. The talk was greatly appreciated and Dr. Hawkins was tendered a rising vote of thanks.

Dr. Egee presented to the Society for its archives an interesting collection of photographs illustrating field trips and activities of the Society in the early days. Mr. Trudell announced the publication of the long awaited CRYSTALLOGRAPHIC TABLES OF MINERALS which have been compiled by Mr. Gordon in conjunction with Professor Goldschmidt of Heidelberg.

J. C. BOYLE, *Acting Secretary*

Academy of Natural Sciences of Philadelphia, May 3, 1928.

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the vice-president, Mr. Boyle, presiding. Thirty-seven members and twelve visitors were present.

Dr. A. B. Gilliland and Mr. H. W. Brandeis were elected to membership. The evening was devoted to a discussion of "*Microscopic Mineralogy*." The subject was introduced by Mr. F. J. Keeley who in his talk traced the development of the mounting of minerals for microscopic examination and display. This idea originated largely from the work of two Philadelphia men, Rev. Rakestraw and George Fiss.

Five microscopes on revolving tables were available and under the direction of Dr. L. C. Wills, the members of the society enjoyed a splendid exhibit of box mounts of minerals.

F. A. CAJORIE, *Secretary*

Academy of Natural Sciences of Philadelphia, June 7, 1928.

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, with the president, Mr. Clay, in the chair. Thirty-three members and six visitors were present.

Mr. E. H. Cienkowski addressed the society on "*The present status of some New England Mineral Localities*." The speaker described in detail a trip taken by him and two of the junior members during Easter week to the following points of mineral interest: Paterson, N. J.; Peekskill and Bedford, N. Y.; Danbury, Conn.; the essonite locality at New Redding was visited, also Branchville, Roxbury, Portland, Haddam Neck, South Glastonbury, Conn.; the datolite locality at Westfield, Mass., and the Chester emery mines. Information was given of the collecting conditions at these localities and a large number of minerals secured on this trip were displayed.

Mr. Cienkowski then introduced the "Junior Minerologists," an organization which has recently been formed by the younger members of the Society. Mr. Morris and Mr. Squiers explained as the purpose of the organization the stimulating of interest in mineralogy among boys of high school age. The activities of the organization will include the publication of a small paper giving items of interest to young mineral collectors.

Mr. Biernbaum reported that both the upper and lower quarries at Paterson, N. J., will open soon but that it was improbable that visitors would be admitted to either. Mr. Squiers reported that the old Phoenixville lead mines are to be covered over as the area in which they are located has been purchased to be used as a hunting ground. Mr. Storck exhibited calcite geodes from the shales at New Brunswick, N. J.

F. A. CAJORI, *Secretary*

NEWARK MINERALOGICAL SOCIETY

Minutes of the Regular Monthly Meetings of February, March, April and May.

On the afternoon of February 5th, Mr. Wm. H. Broadwell read a paper on "*Mercury*." A complete history of this metal was presented covering nomenclature, age, common and rare mineral species containing mercury, uses, (and abuses), etc. All the various mineral species were exhibited. Mr. Broadwell also made the statement that as high as 50 per cent of mercury is being recovered from scrap rubber.

At the March meeting twenty-four members were present. The committee on the New Jersey State list of minerals advised that this work be postponed. Mr. Broadwell reported upon and had on exhibition the latest new mineral from Franklin, calcium-larsenite. He stated that this mineral showed a bright canary yellow fluorescence under the iron arc, quite distinctive from that of willemite.

The April meeting was held on March 29th at Columbia University, New York City, in order to view the Eggleston collection of minerals. Dr. Blank of Columbia University spoke on "*Some Applications of the Polarizing Microscope as Applied to the Identification of Minerals*." At the close of the address the members examined many specimens under microscopes, illustrating the various points brought out in the address.

The May meeting, the last indoor meeting until October, opened with an attendance of twenty-one members. Several reports were given. The Outing Committee reported that a field trip would be arranged for some Sunday in May. Mr. J. G. Manchester then gave a lecture on "*The Artistry of Minerals*." This was illustrated by means of one-hundred colored lantern slides.

Wm. H. Broadwell, *Secretary*